Software challenge blows Crossrail off course

For a decade, construction of London's east-west cross-city tunnel seemed set for completion on time in late 2018. But this deadline has slipped as project promoter Crossrail Ltd grapples with the emerging complexity of delivering a new railway centred on digital technology. Alan Hannaford* reflects on the challenges faced.

When parliament approved London's east-west Crossrail scheme back in July 2008 (RG X.08 p00), there were hopes that the east-west tunnels under London would open by the end of 2017, with the full service proposition, including through running to Reading and Heathrow Airport on the Great Western Main Line, and Shenfield on the Great Eastern, following by mid-2018.

Despite rephasing of the scheme after a change of government in 2010, the aspiration to open the £14·8bn railway by the end of 2018 remained constant for several years, with project promoter Crossrail Ltd remaining confident that this timescale could be met. This bullish outlook endured until August 2018, when reality hit. The line did not open that year, and by the end of last year Crossrail Ltd's stance on an opening date had changed to 'as soon as practicable in 2021'. This was certainly less optimistic than the August 2018 prediction of between October 2020 and March 2021, but still left a wide window for the potential opening.

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Last month, Crossrail's management, led by former London Underground Managing Director Mark Wild, made encouraging but vague noises implying that it had finally got a grip on the project. While the London press made claims about more slippage, Transport Commissioner Mike Brown explained that, for budgetary purposes, the Transport for London board had assumed that Crossrail would open 'late in 2021'.

On January 9, the Crossrail board agreed that a realistic opening date was somewhere in the summer of 2021 for the new build sections linking Paddington with Abbey Wood, with the full service commencing in 'mid-2022'. This is widely assumed to mean May 2022 to coincide with the biannual timetable change, which would constitute a delay of almost two and half years. The budget, meanwhile, had risen from £15·8bn when the Crossrail bill received Royal Assent to £17·8bn by July 2019.

Demanding specification

Inevitably, we must ask what went so wrong on a project that, up to four months before the original planned opening of the central section, was claimed to be on time and only marginally over budget. TfL's official line is that it was the challenge of installing the signalling, but more specifically, it is the installation and

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testing of software of all kinds that has led to a delay that is measured in years.

To create a viable business case for an expensive new railway, the promoters must take full advantage of technology to make maximum use of the capacity created. Often this means using state-of-the-art systems, or sometimes even aspiring to deploy technology which may not yet exist, but is anticipated to be readily available during the timescale of the project.

Crossrail, inevitably, is one such example. The specification required the central section to carry up to 24 trains 200 m long in each direction per hour. On the Network Rail routes linking to the tunnel at either end, the required throughput was 12 trains/h using existing signalling. In addition, the train control system had to interface with platform edge doors in the stations in tunnels, which meant that stopping had to be very accurate. To make things more challenging still, the specification required it to be possible to run 30 trains/h in future should the demand be there. There was no existing train control tool that Crossrail could draw upon which would meet this specification off the shelf.

Given the current state of ETCS deployment in the UK, Crossrail chose to adopt a proprietary CBTC for the core section. This would have to interface with conventional signalling to the east, and with ETCS Level 2 on the western portion where Network Rail was expecting to replace the ex-BR legacy ATP (RG 4.13 p22).

Integration challenge

Crossrail's management knew from the outset that signalling would be the most challenging and riskiest part of the project and made no secret of it. They also understood that a major challenge would be integrating the various different train control systems into a coherent signalling system. Yet with the benefit of hindsight, perhaps an even greater challenge would be interfacing the signalling system with the trains.

The original construction programme allowed around a year for final testing and systems integration, which seemed extremely prudent. But inevitably, the time available started to reduce when construction progress started to slip. As on many railway construction schemes, when the building phase slips a bit, the promoter responds by suggesting time can be made up in the final stages by compressing the testing phase.

But the original leadership team had not really appreciated just how far behind construction work had fallen by the middle of the last decade. More worryingly, Crossrail also appeared not to have understood that over the life of the project, the nature of the risk and complexity had fundamentally altered. The risks were no longer just construction related, but they also

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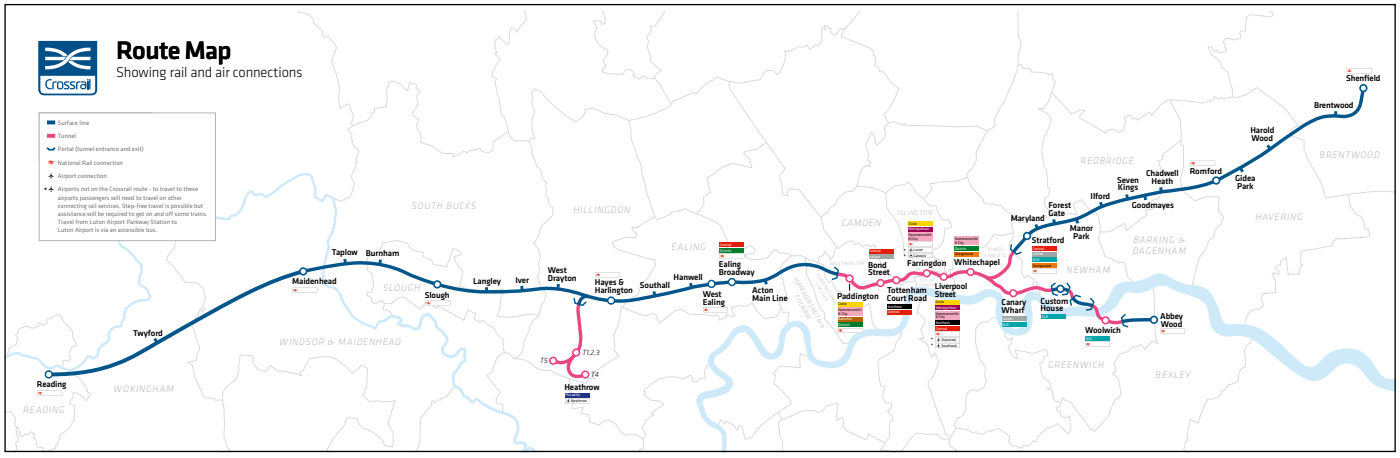

concerned a paradigm shift in the role of digital technology in railway development.

The world had changed

Use of software on the railway is clearly nothing new, having formed part of computer-based signalling systems for decades. What has changed dramatically in the past 10 years is how software has moved to the core of train control systems, to the point where it can no longer be regarded as a set of discreet packages.

This transition is especially evident in the rolling stock sector as suppliers have made software the heart of the modern train, with reams of code controlling everything from doors to passenger information displays to wi-fi provision. These subsystems are also not new, but the transfer of vital signalling functions to onboard processors is.

One wonders how far Crossrail managers had understood at the outset just how software-dependent the Bombardier Aventra fleet ordered for the route would be. The first of 66 Class 345 electric multiple-units entered passenger service on June 22 2017 on the existing TfL Rail service between Liverpool Street and Shenfield, which will eventually be subsumed into Crossrail. The trains ran initially as seven car sets, two vehicles having been removed because of restricted platform lengths at the Liverpool Street terminus.

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Class 345 Bombardier EMUs have been ordered for operation on Crossrail services

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The roll-out of the trains on TfL Rail, while not without teething problems, did not throw up any serious software challenges, which could have reassured Crossrail managers about subsequent phases of the programme. But running trains on the existing railway under legacy lineside signalling with Network Rail's well understood TPWS train protection system was a world away from the multi-system environment the fleet will encounter in squadron service.

The next phase of the Crossrail programme saw the Class 345 EMUs deployed on services from Paddington towards Reading. In theory, this roll-out should have included the former Heathrow Connect service which makes local calls between Paddington and the airport.

While the Heathrow Connect service did indeed transfer to TfL's contractor operator MTR Crossrail in May 2018, it is still being operated with the Siemens Class 360 EMUs inherited from the First Group/Heathrow Airport Ltd joint venture which had run the service since its inception in 2005.

The shortened Class 345 sets were restricted to shuttling between Paddington and Hayes & Harlington. This was because they were not equipped with the legacy ATP fitted in the tunnels between the GWML and the airport.

Adding to the problem was an acute lack of software specialists at Bombardier; those the company did have were busy working on commissioning the nine-car trains for the core Crossrail service and were not available to address the challenge of reaching Heathrow. As a result, the Aventras have still to carry passengers to the airport, although testing is reported to be underway.

MTR Crossrail tentatively started replacing the seven-car trains to and from Hayes & Harlington with nine-car trains, enabling software debugging work to take place on the full length trains. This allowed the start of regular Class 345 operation between Paddington and Reading from the December 15 timetable change. The next objective is to introduce them on services from Paddington to Heathrow Terminal 4 by mid-2020.

London Assembly investigates

When it became clear that Crossrail was going to be late, the London Assembly's Transport Committee launched an investigation. Sir Terry Morgan, the former chairman of Crossrail Ltd, told the committee that Bombardier's trains simply did not work properly when tested with the signalling in the tunnels. He regarded this not as the fault of Crossrail Ltd as project delivery entity, but rather of its parent TfL which procured the trains.

However, it is not clear why Morgan and his team expected that software provided by Bombardier would work 'out of the box' in live conditions with the radio-based CBTC software supplied by Siemens which was being fitted in tunnels that had only just been built. The only way this integration could be truly tested was by running real trains in the tunnels, and the only organisation that could do that was Crossrail.

It must now be asked whether the project promoter could have better anticipated the delay and warned its sponsors, including TfL and the Mayor of London, in advance. Instead, it appears that Crossrail was an inward-looking project with a can-do attitude, so external events did not register as indicating a project risk.

Signs of trouble

Crossrail was not the only UK rail scheme facing these challenges. By 2016, Siemens was already having

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software issues with the introduction of its Class 700 EMUs for the north-south Thameslink route through London (RG 5.15 p44). But unlike the Crossrail fleet, these trains did not have to interface to a novel signalling system before they could commence operation.

Further afield, in November 2017 two trains on the Singapore metro collided while running in automated mode using another supplier’s CBTC, injuring 28 people. This accident could also have served as a warning to Crossrail about how much emphasis needed to be placed on thorough testing — a procedure that cannot be rushed.

The following year, software problems emerged with the Class 710 Aventra trainsets being supplied by Bombardier for TfL’s London Overground operation. Although not technically identical, the LO trains shared a common design platform with the Crossrail fleet; the LO introduction was delayed by more than a year.

Meanwhile, the deployment of CBTC on London Underground’s sub-surface lines was also struggling, despite having been retendered twice in a decade. Contractor Thales was reportedly having problems making trackside and onboard equipment communicate seamlessly on a relatively self-contained 2·5 km section of the Circle Line.

Progress with the Four Lines Modernisation has now seen further sections commissioned, including two key junctions (RG X.19 p00), and Thales now expects the full resignalling to go live in 2023, seven years after the start of work. Seen in this context, Crossrail’s allocation of a year for testing and commissioning suddenly looked ominously brief.

End in sight

At the start of 2020, the Crossrail management team can at least be relieved that construction now is largely complete, with the constrained station at Whitechapel the last major element to be finished on the new-build sections. Contractors have faced various late-stage problems over recent months, notably relating to non-railway-compliant fire systems and remedial work arising from knowledge gained as a result of the Grenfell residential tower fire in west London in 2017.

Overcoming these last hurdles in the civils programme is critical, since fully integrated testing of components such as smoke suppression and platform screen doors cannot start until construction is functionally complete.

Perhaps the most daunting hurdle left relates to assurance and certification. Like the train control integration, there needs to be recognition from management about how enormous a task this will be. The process must be completed sequentially, unlike in the wider construction sector where certification tasks can often be undertaken concurrently with other commissioning work. In the rail sector this tends not to be possible, although it seems the original Crossrail management team had hoped it could be.

Crossrail Ltd now expects to start trial running through the cross-city core in ‘autumn 2020’. This involves simulating a full timetabled service through the central tunnels; at the time of writing, trains can already run in the tunnels and each software iteration brings an accurate recreation of the planned timetable closer to fruition. Given the promoter’s new-found confidence, it is reasonable to assume the train control software and integration is at the point where it needs only relatively small tweaks to deliver a viable service.

By the end of this year, we are likely to see the first test runs in the core carrying invited guests to simulate the real world conditions, while Network Rail’s outstanding station work west of Paddington should also be completed by the end of 2020. This would leave just two surface stations left for major refurbishment, at Ilford and Romford on the GEML. Work at both is expected to be completed by the end of 2021.

If Crossrail can open phase 3 of the programme (Paddington – Abbey Wood) by the middle of 2021, this should give enough time for the service — which will then be rebranded from TfL Rail to Elizabeth Line — to settle down so that the Shenfield – Paddington (phase 4) service could start with the December 2021 timetable change. This should then make completion of phase 5b (through trains to Reading and Heathrow Terminal 4) possible from the May 2022 timetable.

While this would essentially complete the roll-out, there remains the unanswered question of when the Elizabeth Line will reach Heathrow Terminal 5, currently only served by Heathrow Airport Ltd’s premium Heathrow Express and London Underground. Additional trains have been procured by TfL for a 2 trains/h service, but no date has yet been suggested for it to start.

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